Comments on "Warm Cloud Electricity in a Shallow Axisymmetric Cloud Model"

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14 April 1980 and 7 May 1980

Takahashi (1973, 1974, 1977, 1979) has recently presented experimental evidence that as a drop of water evaporates or grows by condensation there is a steady change of surface potential, and has incorporated this effect into cloud electrification models. Since such a mechanism would appear to be of widespread and fundamental importance, it is perhaps relevant to examine the process in a little more detail. In the experiment (Takahashi, 1973) the change in surface potential was measured as water was allowed to condense onto and to evaporate from a copper electrode. This change in potential was interpreted as a change in the dipole layer at the water-air interface. Changes in potential across the copper-water interface were not considered, although it is well known (Hobbs, 1974) that this potential can vary in an unpredictable and erratic manner.

Let us assume that the dipole layer at the surface of evaporating and condensing water drops is indeed very different, and consider what will happen to an isolated uncharged drop in air containing positive and negative ions. Fig. 2 in Takahashi (1979) suggests that if the dipole layer has the positive charges directed outward, then negative ions are attracted toward the surface and positive ones repelled; thus the drop acquires negative charge. The cause of this effect needs clarification. It cannot be electrostatic because, irrespective of any surface dipoles, an isolated conductor with no net charge will have no radial field. (A field could exist for a supported drop in the laboratory because of contact potentials.) If both signs of ion are equally incident on the surface, but for some reason the negative ones stick and the positive ones "bounce off," then it might be possible for the drop to acquire a potential of one-fortieth of a volt. Any higher voltage and the ions would not have enough thermal energy to climb up the potential hill (their kinetic energy will be negligible); for a drop of 1 mm radius this is equivalent to a charge of only $\sim 2 \times 10^{-15}$ C. However, a consideration of the image forces alone

0022-4928/80/122795-02$4.50

would suggest that ions of both signs should attach to the water drop.

At present it is not clear that the surface potential of a drop of water does change as it condenses or evaporates, and even assuming that it does, the processes which would result in an isolated drop acquiring a net charge because of this potential change still remain to be identified. Meanwhile, the results from models incorporating this charging mechanism should be treated with great caution.

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